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Anterior thoracoscopic surgery followed by posterior instrumentation and fusion in spinal deformity

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Abstract Many authors believe thoracoscopic surgery is associated with a lower level of morbidity compared to thoracotomy, for anterior release or growth arrest in spinal deformity. Others believe that anterior release achieved thoracoscopically is not as effective as that achieved with the open procedure. We evaluated the clinical results, radiological correction and morbidity following anterior thoracoscopic surgery followed by posterior instrumentation and fusion, to see whether there is any evidence for either of these beliefs. Twenty-nine patients undergoing thoracoscopic anterior release or growth arrest followed by posterior fusion and instrumentation were evaluated from a clinical and radiological viewpoint. The mean follow-up was 2 years (range 1–4 years). The average age was 16 years (range 5–26 years). The following diagnoses were present: idiopathic scoliosis (*n* = 17), neuromuscular scoliosis (*n* = 2), congenital scoliosis (*n* = 1), thoracic hyperkyphosis (*n* = 9). All patients were satisfied with cosmesis following surgery. Twenty scoliosis patients had a mean preoperative Cobb angle of 65.1° (range 42°–94°) for the major curve, with an average flexibility of 34.5% (42.7°). Post operative correction to 31.5° (50.9%) and 34.4° (47.1%) at maximal follow-up was noted. For nine patients with thoracic hyperkyphosis, the Cobb angle averaged 81° (range 65°–96°), with hyperextension films showing an average correction to 65°. Postoperative correction to an average of 58.6° was maintained at 59.5° at maximal follow-up. The average number of released levels was 5.1 (range 3–7) and the average duration of the thoracoscopic procedure was 188 min (range 120–280 min). There was a decrease in this length of time as the series progressed. No neurologic or vascular complications occurred. Postoperative complications included four recurrent pneumothoraces, one surgical emphysema, and one respiratory infection. Thoracoscopic anterior surgery appears a safe and effective technique for the treatment of paediatric and adolescent spinal deformity. A randomised controlled trial, comparing open with thoracoscopic methods, is required.

Key words Spinal deformity · Thoracoscopic release and posterior instrumentation

Introduction

Thoracoscopic anterior surgery is becoming increasingly popular in the treatment of spinal deformity. Despite enthusiasm for this minimally invasive technique, there are relatively few clinical trials [9, 10, 11,13] reporting clinical and radiological outcome after such procedures. Most authors describe isolated case reports or experimental results only on animals [1, 2, 3, 4, 7, 8, 15, 16, 18]. An advantage of thoracoscopy is the reduced morbidity, which is thought to prevent postoperative pain at the thoracotomy site [5].

The purpose of this study was to evaluate the efficacy and safety of thoracoscopic anterior release or growth arrest in a series of consecutive patients with a scoliotic or kyphotic deformity, specifically with respect to the clinical and radiological outcome.

Materials and methods

Twenty-nine patients undergoing thoracoscopic anterior release or growth arrest followed by posterior instrumentation and fusion between 1995 and 1997 underwent clinical examination and radiological analysis of the frontal and sagittal plane pre- and postoperatively and at maximal follow-up (mean 2 years, range 1–4 years).

The following data were recorded for each patient: aetiology of curve, type of deformity (King classification, kyphosis), length and extent of primary and secondary curves, age at the time of operation, thoracoscopic procedure time, number of levels released, length and extent of the instrumented fusion, blood loss (thoracoscopic and posterior), intercostal drainage times, analgesic use, length of hospital stay and all complications. For radiographic evaluation, frontal and lateral standing radiographs were available preoperatively, postoperatively, and at the maximal follow-up. For measurement of curve flexibility, bending or hyperextension films were obtained preoperatively.

The average age was 16 (range 5–26) years; there were 12 male and 17 female patients. Seventeen patients had an idiopathic scoliosis: eight had King type II, seven King type III, one King type IV and one King type V. Two patients had neuromuscular scoliosis, one had congenital scoliosis eight had Scheuermann’s kyphosis, and one patient had kyphosis after resection of the posterior elements of the spine during childhood for a Ewing’s sarcoma.

In 22 patients an anterior release was performed, and in 7 patients an additional anterior growth arrest was performed. Twenty-six patients were instrumented posteriorly using the Universal Spine System (Synthes, Switzerland) and three had a Luque trolley instrumentation with sublaminar wires. In all but one case, posterior instrumentation and fusion followed the thoracoscopic procedure under the same anaesthesia. In this one case (King III idiopathic scoliosis), concern about respiratory status led to the postponement of posterior surgery by 1 week.

Thoracoscopic technique

All patients were intubated with a double lumen cuffed endotracheal tube, to allow one lung ventilation while thoracoscopic anterior surgery was performed. The patient was placed in the lateral position with wide preparation and drape to allow conversion to an open procedure if necessary. After the lung on the operated side was deflated, portals (usually three or four) were positioned. In scoliosis patients we used the midaxillary line to place the portals, and in kyphotic patients the posterior axillary line was used. In small patients we preferred to place the portals in an L-shape in order to avoid crossing of the trocars. We used a rigid endoscope with a 30°-angle lens (Storz, Tuttlingen, Germany). The parietal pleura was incised using electrocautery. If haemostasis could not be achieved with cautery alone, vascular clips were used. The discs were opened with electrocautery, and then excised using pituitary forceps, various curettes and Kerrison rongeurs. In the case of an anterior release, the intervertebral spaces were packed with gelfoam, and in the case of an anterior growth arrest, autologous bone graft was packed into the disc space. In closing, the pleura was not routinely sutured. A chest drain was inserted, usually through one of the trocar sites, with other trocar sites closed routinely with sutures.

Results

Clinical results

All 29 patients were followed up for a mean of 2 years (range 1–4 years). All patients were satisfied with their cosmesis following surgery.

The average time for the endoscopic procedure was 188 min (range 120–280 min). This time decreased as the series progressed. The overall operating time was a mean of 470 min (range 420–730 min). The mean blood loss was 2374 ml (range 840–4000 ml), made up of an average of 342 ml (range 100–1000 ml) from the thoracoscopic procedure and an average of 2032 ml (range740–3000 ml) from the posterior instrumentation and fusion. The mean number of released/growth arrest levels was 5.1 (range 3–7). In no case was a conversion to open thoracotomy necessary. There were no neurologic or vascular complications. The chest drain was removed on average 3 days after the procedure (range 2–5 days). Postoperative analgesia included morphine (average 120 mg, range 60–240 mg) delivered intravenously over a 3- to 4-day period, via a patient controlled analgesia (PCA) pump. Adjuvant analgesics taken during hospital admission included paracetamol (mean 23 g, range 14–40 g), dihydrocodeine (mean 270 mg, range 120–600 mg) and diclofenac (mean 700 mg, range 150–1500 mg). The average hospital stay was 8.6 days (range 6–18 days). All patients were mobilised without a brace in the postoperative period.

Postoperative complications included four recurrent pneumothoraces (three of which required insertion of a chest drain), one surgical emphysema, and one chest infection.

Two patients underwent revision surgery: The first patient required extension of posterior fusion from L1 to L3 for progressive caudal deformity; in retrospect the original fusion (T4–L1) was too short. The second patient reported back pain at 12 months. The posterior metalwork was removed and the deformity re-occurred to a lesser degree (Cobb angle 50°), due to a pseudarthrosis. A posterior revision (T4–L3) with costoplasty was carried out. The final outcome was excellent, with the patient painfree and pleased with the cosmesis. No patient required anterior revision.

Radiological results

Frontal plane

Twenty patients with scoliosis had an average preoperative Cobb angle for the major curve of 65.1° (range 42°–94°). With bending films, this corrected to 42.7° (flexibility 34.5%). The mean postoperative correction of the major curve was 31.5° (50.9%), and 34.4° (47.1%) at maximal follow-up. The mean upper compensatory curve was 39.8° preoperatively, 27.3° postoperatively and 30° at maximal follow-up. The mean lower compensatory curve was 46.2° preoperatively, 28° postoperatively and 29.1° at maximal follow-up. The tilt of the lowest instrumented vertebra was corrected from 19.7° to 8.5°, without notable changes at follow-up. Frontal plane decompensation averaged 1.7 cm preoperatively, changing to 1.5 cm at final follow-up. Radiographically, all segments appeared fused. The average length of curve was 8.95 segments and the average fusion length was 10.95 segments.

Sagittal plane

In the scoliosis group (n = 20), the mean thoracic kyphosis (measured between T4 and T12) was 40° preoperatively, 28.2° postoperatively and 34.2° at maximal follow-up. The thoracolumbar junction (T10–L2) showed a mean lordosis of –1.2° (range –12° to +14°) preoperatively and –7.6° at follow-up. The lumbar lordosis (L1–L5) was –42.1° preoperatively and –43.1° postoperatively without relevant changes at follow-up.

Idiopathic scoliosis

In the 17 patients with idiopathic scoliosis, the major curve averaged 61.8° (range 42°–90°) preoperatively, reducing to 42° on bending films (average flexibility 31.9%). The curve was corrected to 31.1° (49.6%) postoperatively and 34.2° (44.5%) at follow-up.

Eleven of these 17 patients had an anterior release because of insufficient flexibility on the bending films. The average age in this group was 17.5 years (range 14–26 years). The major curve measured 69.2° (range 48°–90°) on average, reducing only to 50.7° on bending films (flexibility 26.7%). A postoperative correction of the major curve to 36.4° (47.3%) was achieved. This measured a mean of 39.5° (42.8%) at maximal follow-up.

Six of the 17 patients with idiopathic scoliosis (Risser 0–1) had an anterior growth arrest in addition, because of skeletal immaturity, to prevent a crankshaft phenomenon. The average age was 10.5 years (range 5–13 years). The major curve averaged 48.2° (range 42°–62°) correcting to 27.7° on the bending films (flexibility 42.5%). The postoperative correction was 21.3° (55.8%) and at follow-up it was 27.5° (42.9%). In this group, two patients showed marked loss of correction. The first one (King type III)

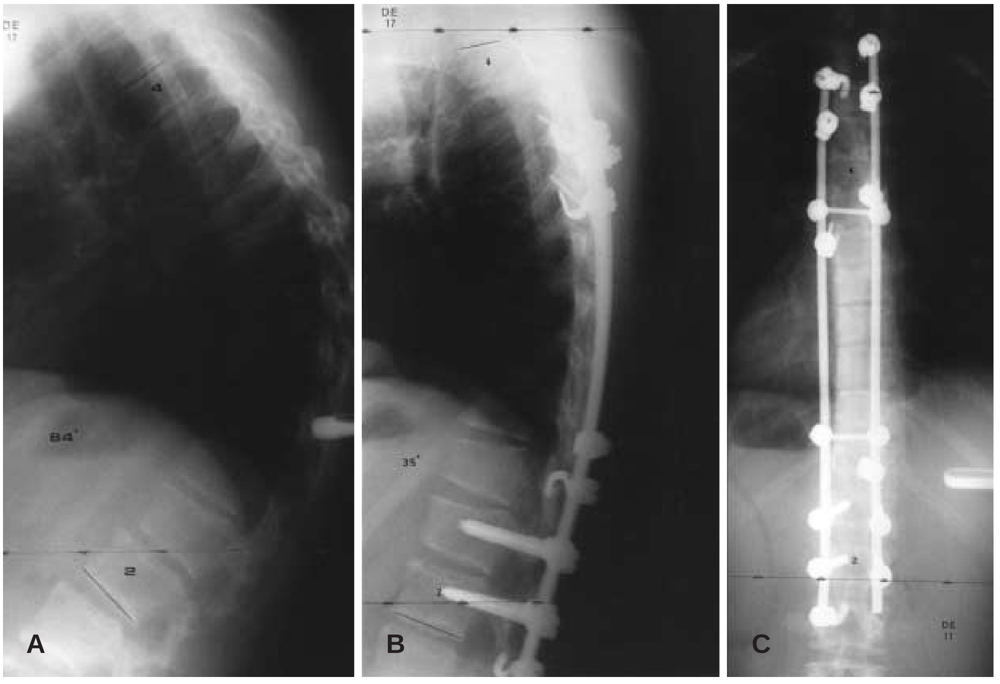

Fig. 1 A–C A 17-year-old male patient with Scheuermanns thoracic hyperkyphosis of 84° Cobb angle between T2 and T12. **A** Pre-operative radiograph. **B, C** Follow-up radiographs, 2 years after surgery, showing a good sagittal correction of 35°, following thoracoscopic release and posterior instrumentation and fusion from T2 to L3

was operated early on in the series, and did not receive a sufficient growth arrest. Within the instrumentation (T5–L1), the curve progressed from 16° postoperatively to 48° at 24 months. At follow-up (48 months) there was no further progression, and the patient was simply kept under observation. The second patient (King type III) showed caudal progression of the deformity 18 months postoperatively. This was due to the original fusion being too short. There was no loss of correction within the instrumentation (T4–L1). The patient was revised, with the instrumentation extended to L3.

Hyperkyphosis

Thoracic hyperkyphosis averaged 81° (range 65°–96°) in nine patients. On hyperextension films, this corrected to 65° (flexibility 19.7%). Postoperative correction was 58.5° on average and 59.6° at follow-up. The thoracolumbar junction (T10-L2) was 8° preoperatively (range –30° to +44°) and showed a correction to 4.4° postoperatively without a change at follow-up (Fig. 1). The lumbar lordosis (L1–L5) decreased from –58.4° to –51.3° postoperatively, again with no change at follow-up.

At time of follow-up, the three patients with Luque trolley instrumentation showed stable instrumentation with no progression of the deformity.

Discussion

Thoracoscopic anterior release for rigid spinal deformity is considered to have many advantages over open thoracotomy. It is less invasive, limiting the skin and muscle dissection normally required for thoracotomy. Many authors claim that equal flexibility of the curve can be obtained with the thoracoscopic technique when compared to open procedures [1, 2, 3, 4, 9, 14, 18, 20]. However the technique is technically demanding, time consuming, and has a learning curve [7, 11, 12]. Some authors claim the endoscopic technique fails to provide sufficient exposure to remove discs safely and completely gain sufficient flexibility [7, 13].

The aim of thoracoscopic anterior release is to improve the mobility of rigid motion segments within the curve, in order to achieve sufficient correction with the posterior instrumentation. In our series, the 17 patients with idiopathic scoliosis showed an average flexibility of 31.9% on the bending films. The major curve was corrected from 61.8° to 31.1° (49.6% correction) postoperatively, and measured 34.2° (44.5% correction) at maximal follow-up. Within this group 11 mature patients with rigid curves showed a flexibility of only 26.7% on bending films. The major curve was corrected from 69.2° to 36.4° (47.3% correction) postoperatively and measured 39.5° (42.8% correction) at maximal follow-up. Due to the anterior release, the frontal plane correction improved by 20.6%. These results, compared to reports on stand-alone posterior instrumentation [6, 17], suggest that increased flexibility achieved by anterior thoracoscopic release allows for greater correction of the primary curve. Some authors have attempted to compare the results of thoracoscopic anterior release to open thoracotomy. Newton et al. in 1997 [9] reported on a group of seven patients with an average correction of 56% in the thoracoscopic group compared to an average correction of 60% in the open thoracotomy group. In both groups, posterior instrumentation was performed either on the same day or as a staged procedure. Pollock et al. [14] describe a larger series of patients (n = 42), with no significant difference in the correction obtained between a thoracoscopy group and a thoracotomy group. Similarly, Papin et al. [13] found no significant differences between a group of eight cases of thoracoscopic anterior release followed by posterior instrumentation and an open group. However the authors recommend that anterior release should be performed through a formal thoracotomy, allowing a more complete disc excision with shorter surgical time and a similar morbidity level to the thoracoscopic group. It is generally accepted that in flexible curves (48°–50°) it is not necessary to consider a thoracoscopic release.

Gonzalez Barrios et al. [3] reported on two patients treated with posterior instrumentation followed by anterior growth arrest, who subsequently developed a crankshaft phenomenon during follow-up. For our patients who had an anterior growth arrest, initial correction of the curve was good (55%), but this dropped to 42.9% correction after 2 years. One patient presented with a crankshaft phenomenon, which led to loss of correction of 20° within the fusion. With hindsight, the growth arrest performed was insufficient. In a second patient, the instrumentation was too short, and needed extension 1 year later.

Thoracoscopic anterior release may also be considered to be an alternative to open procedures for rigid thoracic hyperkyphosis. In our study, thoracic hyperkyphosis averaged 81° (range 65°–96°) in nine patients, correcting to 65° on the hyperextension films. The mean Cobb angle postoperatively was 58.5°, and it was 59.6° at maximal follow-up. Our results may reflect the difficulties in correcting kyphotic deformities. Sclerosis and fibrotic change within the anterior and posterior longitudinal ligament and the disc result in narrowing of the intervertebral space, making endoscopic removal of disc material difficult. In kyphosis, visualisation of the apex may be difficult, as it is directed away from the endoscope, unlike scoliosis, where the apex generally is directed towards the scope. Newton et al. [9, 11] instead report very good results of correction in their series, and did not describe such technical difficulties.

One argument for thoracoscopy has been the reduced morbidity as compared to open thoracotomy [1, 2, 3, 4, 9, 10, 11, 12, 15, 16, 18]. At present, however, there are only three large clinical trials [9, 13, 14] published that compare thoracotomy to thoracoscopy in the treatment of spinal deformity. Newton et al. [9] did not prove that the thoracoscopic group had less blood loss or a lower complication rate. In fact, the intercostal chest drain output was greater in the thoracoscopic group than in the open group. The hospital stay was not reduced for the minimally invasive group. Rothenberg et al. [18] believe that earlier extubation and chest tube removal is evidence enough for a reduced morbidity. There was no control group in their study. They stated that the majority of cases were extubated on the 1st postoperative day. In our series, all patients were extubated on the same day, and the average intercostal drainage time was 3 days, as in many other studies [1, 2, 3, 4, 7, 9, 10, 11, 12, 13, 16]. In our series, three cases required intercostal drain reinsertion for recurrent pneumothoraces. Papin et al. [13] stated that their results diminished the initial enthusiasm about thoracoscopy. Despite the minor surgical trauma to the chest wall, none of the clinical or radiological results that have been investigated have shown reduced morbidity. Pollock et al. [14] studied lung function parameters, and found no significant differences between the groups. Newton et al. [9] mentioned that they sutured the pleura after completing discectomy. This may reduce intercostal drainage, but would undoubtedly prolong the procedure times. Regan et al. [15, 16] do not mention suturing of the pleura in their series of four deformity patients.

Several authors mentioned that thoracoscopy is a time-consuming procedure. The scope times reported in several publications lie between 106 and 473 min [4, 5, 6, 7, 9, 10, 11, 16]. We noticed a significant reduction in the thoracoscopic procedure time as the series progressed – an experience that has been shared by many others [1, 2, 3, 4, 7, 9, 10, 11, 12, 14, 18, 20]. Newton et al. [9] found that the learning curve based on the operative time per disc reached a plateau after 30 cases. Performing thoracoscopy and fusion as a staged operation cannot be a preferred option. Even longer scope times should not be a bar to performing anterior and posterior surgery on the same day, as this would minimize the advantages of minimally invasive surgery and would only lead to a prolonged stay.

The blood loss from the thoracoscopic procedure in our series averaged 342 ml (range 100–1000 ml). This is in keeping with the literature; a range of between 150 and 500 ml has been reported by various authors [1, 2, 3, 4, 7, 9, 10, 11, 12, 14, 18, 20].

In general, we found postoperative analgesia perfectly adequate, with intravenous morphine bolus, delivered by a patient-controlled analgesia pump, supplemented with adjuvant oral analgesics including paracetamol, dihydrocodeine and diclofenac. We had no cases of severe post-thoracotomy pain. Long-term pain with open thoracotomy may not be as severe as originally thought, according to Salzer et al. [19]. In children, post-thoracotomy painful syndrome does not seem to occur, and in adults it is far from common. In our series, patients were pleased with their overall cosmetic appearance and, in particular, found the scars from the thoracoscopic portals perfectly acceptable.

Neuromuscular scoliosis seems to be less appropriate for thoracoscopic procedures. These patients often have impaired lung function to start with, and may not tolerate the longer operating time. However the early pain associated with an open thoracotomy in these patients may further compromise lung function, and so must be weighed up when considering which approach to use. We treated two patients with cerebral palsy, and had no specific problems with respiratory compromise. Newton et al. [9], however, encountered two patients with cerebral palsy who required prolonged ventilatory support. We had one case in which the second stage surgery was postponed by 1 week because of concern about ventilation. This was, in fact, an idiopathic scoliosis (King III, Cobb angle 81°) and had abnormal pulmonary function tests pre-operatively.

Conclusion

Thoracoscopy is an exciting novel technique gaining acceptance in the treatment of some paediatric and adolescent spinal deformities. The technique itself appears safe and effective in the hands of experienced surgeons. Morbidity appears at least as low as with open thoracotomy, and may even be reduced. We feel the technique has a good cosmetic outcome, with high patient satisfaction. The indications are limited, however, and in our opinion, thoracoscopic anterior release should be considered for scoliotic and kyphotic curves with a Cobb angle greater than 60°, where the bending films indicate less than 50% correction. In addition, it appears that satisfactory growth arrest can be performed thoracoscopically in immature patients, at the risk of developing a crankshaft phenomenon. However, with this series, it is impossible to conclude that it is superior to posterior instrumented correction and fusion alone. A word of caution from Regan and Guyer [16]: ‘Not all procedures may be applicable to minimally invasive approaches and just because a procedure can be done, does not mean that it should be done.’ Clearly there is now the need for a formal randomised controlled study comparing open thoracotomy/anterior release/growth arrest with thoracoscopic anterior release/growth arrest from both a clinical and radiological viewpoint, with a minimum 2-year follow-up.

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